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Maritimes Region

Canadian Science Advisory Secretariat
Science Response 2015/002

SCALLOP (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY: STOCK STATUS UPDATE FOR 2014

Context

The objectives of this meeting were to: identify the consequences of different harvest levels in Scallop Production Areas (SPAs) 1A, 1B, 3, and 4 for the 2014/2015 season, and provide advice on the initial harvest levels for the start of the 2015/2016 season for SPAs 1A, 1B, 3 and 4, and, identify all information on fishery by-catch of non-target species, and, if information is available, identify any notable changes in occurrence of bycatch species relative to previous years. Initial harvest levels are provided for the following fishing year to allow the fishery to start in October before annual assessment or update results are available.

This Science Response Report results from the Science Response Process of 28 November 2014 on the Bay of Fundy Scallop Stock Status Update.

Background

Population surveys are conducted annually by Fisheries and Oceans Canada (DFO) Science. The population dynamics of commercial and recruit scallops for all SPAs (excluding 6; Appendix 1) were modelled using a Bayesian state-space model with modifications presented in Smith et al. (2012) and Smith and Hubley (2014). In this report, scallops with a shell height of 80 mm and greater will be referred to as commercial size and scallops with a shell height of 65-79 mm will be referred to as recruits, and are expected to grow to be commercial size in the following year. Scallops less than 65 mm are defined as pre-recruits. Scallop removals accounted for in assessments include landings from the inshore scallop fleets and Food, Social and Ceremonial (FSC) catch when applicable. Landed recreational and FSC catch by dip netting, diving, tongs, and hand are not recorded and, therefore, not available. There was no FSC catch by drag gear in the Bay of Fundy in the 2014 fishing year. The last full assessment of the Bay of Fundy scallop took place in 2013 (DFO 2014, Nasmith et al. 2014).

Description of the Fishery

The Bay of Fundy inshore scallop fishery is fished by three scallop fleets: Full Bay, Mid Bay, and Upper Bay. Full Bay license holders are permitted to fish throughout the Bay of Fundy. Mid Bay license holders have access to all areas north of the Mid Bay line. Upper Bay license holders are restricted to the upper reaches of the Bay. The fishery is managed using limited entry, drag gear size limits, seasonal closures, minimum shell height, and meat count. The drag gear width limit is 5.5 m with a ring size of not less than 82 mm inside diameter. The Full Bay Fleet operates under an Individual Transferable Quota (ITQ) system. The Mid Bay and Upper Bay fleets fish with competitive quotas. Total Allowable Catches (TACs) are set and landings are reported in terms of meat weights (adductor muscles).

Analysis and Conclusions

Scallop Production Area 1A

The Full Bay fleet caught a total of 274.48 tonnes (t) against a TAC of 275 t during the 2014 fishery in SPA 1A. Commercial catch rate in the 2014 fishing year was 22.3 kilograms per hour (kg/h), an increase from 2013 (20.5 kg/h) and above the long-term (1998 to 2013) median of 15.45 kg/h. Condition factor (measured in grams per cubic decimeter (g/dm^3)) in 2014 was 13.3 g/dm^3, a decrease from 2013 (14.5 g/dm^3), and above the long-term (1996-2013) mean of 12.3 g/dm^3. Pre-recruits were most abundant in the 8 to 16 mile survey strata (Figure 1 and Appendix 1). Biomass estimates for recruit scallops increased from 47.7 t in 2013 to 166.1 t in 2014, which was well above the long-term (1997-2013) median of 52 t. Most of the increase for recruits was seen in the 8 to 16 mile survey strata (Figure 2 and Appendix 1). Distribution of commercial scallop biomass was patchy in the Middle Bay South stratum and more evenly distributed in other parts of SPA 1A (Figure 3). Commercial population biomass for 2014 estimated by the model was 2,005 t (meats) which is in the healthy zone (Figure 4).

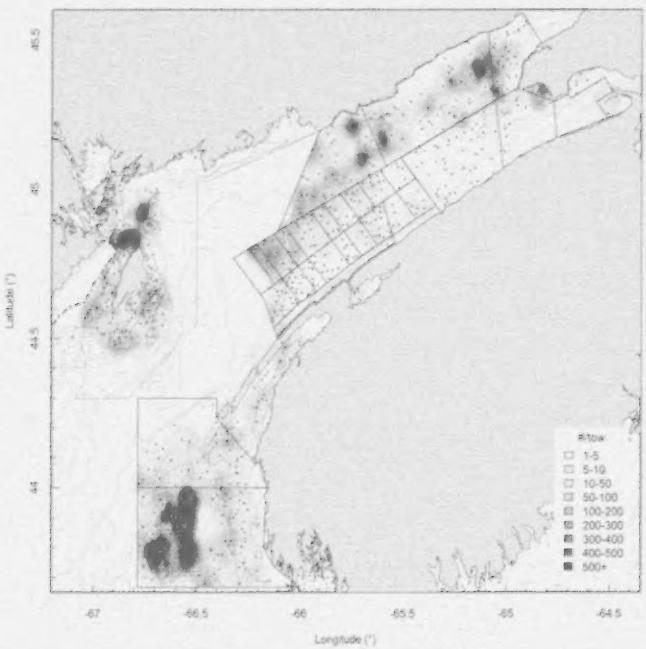

Figure 1. Spatial distribution (number/tow) of pre-recruit scallops (< 65 mm shell height) in the Bay of Fundy and approaches in 2014. Black lines are survey strata. Red lines delimit vessel monitoring system (VMS) areas, with areas inside the VMS lines corresponding to high fishing effort and areas outside the VMS lines corresponding to low fishing effort (see: Smith et al. 2012).

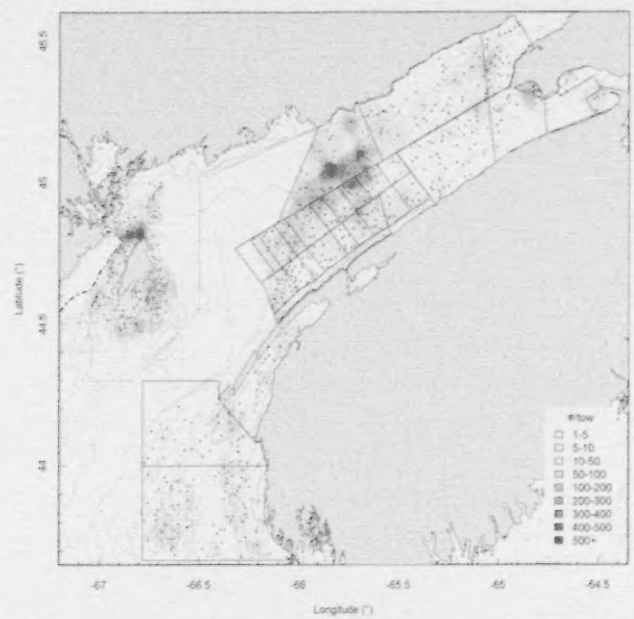

Figure 2. Spatial distribution (number/tow) of recruit scallops (65-80 mm shell height) in the Bay of Fundy and approaches in 2014. Black lines are survey strata. Red lines delimit vessel monitoring system (VMS) areas, with areas inside the VMS lines corresponding to high fishing effort and areas outside the VMS lines corresponding to low fishing effort (see: Smith et al. 2012).

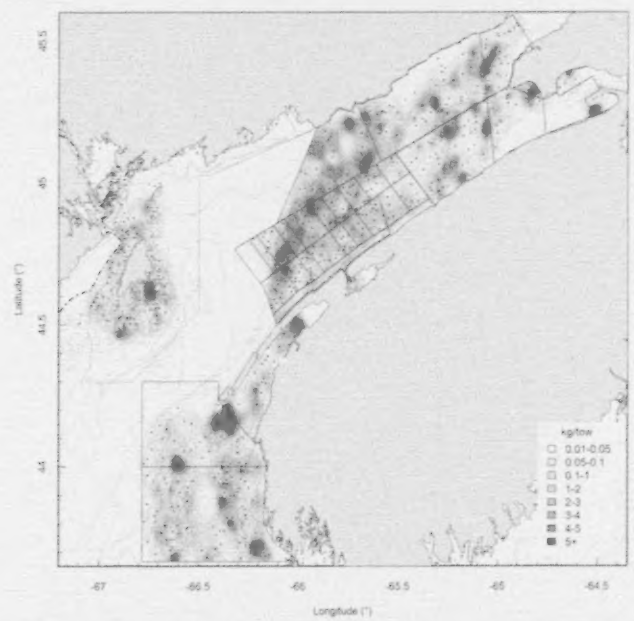

Figure 3. Spatial distribution of commercial (> 80 mm shell height) biomass (kg/tow) in the Bay of Fundy and approaches in 2014. Black lines are survey strata. Red lines delimit vessel monitoring system (VMS) areas, with areas inside the VMS lines corresponding to high fishing effort and areas outside the VMS lines corresponding to low fishing effort (see: Smith et al. 2012).

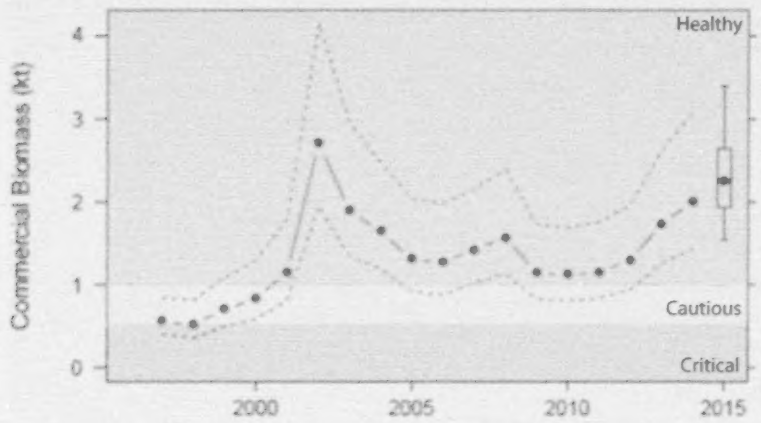

Figure 4. SPA 1A biomass estimates for commercial size scallops (kt) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2015, assuming the 2014/2015 initial TAC (150 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). Green-shaded area represents the healthy zone (based on a Upper Stock Reference (USR) point of 1000 t), yellow area represents the cautious zone (based on Lower Reference Point (LRP) of 525.5 t) and red is the critical zone (< LRP).

Table 1. Harvest scenario table for SPA 1A to evaluate 2014/2015 catch levels in terms of resulting exploitation (e), expected changes in biomass (%), probability of biomass decline, probability that after removal the stock will be above the USR (1000 t), and above the LRP (525.5 t). Potential catches (t) in 2015/2016 are evaluated in terms of the posterior probability of exceeding exploitation rate of 0.15.

2014/2015						Potential catch (t) 2015/2016 $Pr(e_{2015/2016}) > 0.15$					
Catch (t)	e	% Change	Pr Decline	Pr > USR	Pr > LRP	0.1	0.2	0.3	0.4	0.5	0.6
150	0.06	12.03	0.31	0.99	>0.99	254	297	333	367	402	438
175	0.07	10.57	0.33	0.99	>0.99	249	295	331	363	398	436
200	0.08	9.15	0.35	0.99	>0.99	248	291	327	359	393	430
225	0.09	8.03	0.36	0.99	>0.99	246	287	322	354	388	427
250	0.10	6.54	0.39	0.99	>0.99	242	284	320	352	385	423
275	0.11	4.96	0.41	0.99	>0.99	236	279	315	348	380	416
300	0.13	4.05	0.43	0.99	>0.99	235	278	312	345	377	414
325	0.14	2.61	0.45	0.99	>0.99	230	272	307	338	371	409
350	0.15	1.29	0.48	0.99	>0.99	227	268	301	333	367	402
375	0.16	0.01	0.50	0.98	>0.99	224	266	299	331	362	398

Scallop Production Area 1B

The total 2014 landings for all fleets in SPA 1B was 496.53 t against a combined TAC of 450 t. Catch rates for the Full Bay Fleet did not change from 2013 in Scallop Fishing Areas (SFAs) 28B (26.5 kg/h), 28C (26.3 kg/h), and 28D (25.9 kg/h). Catch rates for the Mid Bay Fleet increased in both SFAs 28B (18.3 kg/h in 2013 to 27.96 kg/h in 2014), and 28C (19.95 kg/h in 2013 to 25.4 k/gh in 2014). Catch rates for the Upper Bay Fleet increased in both SFAs 29C (18.8 kg/h in 2013 to 20.5 kg/h in 2014) and 28D (17.8 kg/h in 2013 to 19.9 kg/h in 2014). Condition from the survey decreased in all three SFAs, most dramatically in 28C and 28D. Over the entire SPA, condition decreased from 13.7 g/dm^3 in 2013 to 11.8 g/dm^3 in 2014, and was slightly below the long-term (1996-2013) mean of 12.1 g/dm^3. High density patches of pre-recruits were observed throughout SPA 1B (Figure 1). The recruit biomass

estimate increased from 214.4 t in 2013 to 461.1 t in 2014, and was well above the long-term (1997-2013) median of 123.8 t. The highest abundance of recruits was seen in the Cape Spencer survey stratum (Figure 2 and Appendix 1). Commercial biomass was patchy in SPA 1B with many beds of high biomass (Figure 3). Commercial population biomass for 2014 estimated by the model was 2,730 t (meats), which is in the healthy zone (Figure 5).

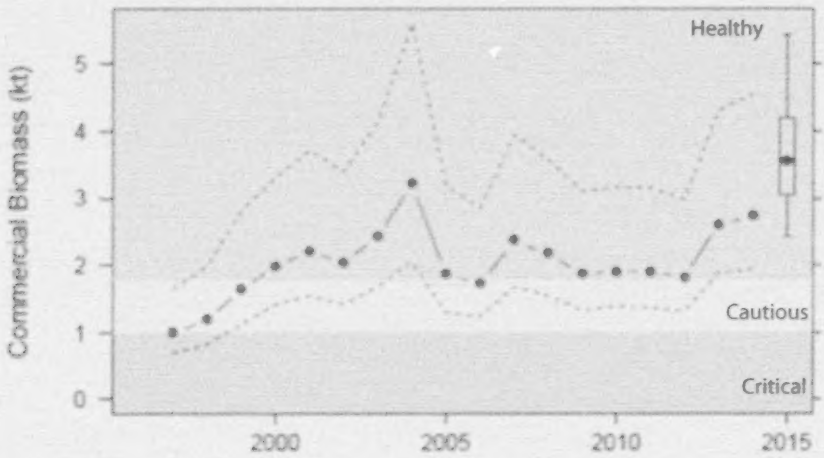

Figure 5. SPA 1B biomass estimates for commercial size scallops (kt) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2015, assuming the 2014/2015 initial TAC (150 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). Green-shaded area represents the healthy zone (based on a USR of 1800 t), yellow area represents the cautious zone (based on LRP of 988.4 t) and red is the critical zone (< LRP).

Table 2. Harvest scenario table for SPA 1B to evaluate 2014/2015 catch levels in terms of resulting exploitation (e), expected changes in biomass (%) , probability of biomass decline, probability that after removal the stock will be above the USR (1800 t), and above the LRP (988.4 t). Potential catches (t) in 2015/2016 are evaluated in terms of the posterior probability of exceeding exploitation rate of 0.15.

2014/2015						Potential catch (t) 2015/2016 $Pr(e_{2015/2016}) > 0.15$					
Catch (t)	e	% Change	Pr Decline	Pr >USR	Pr >LRP	0.1	0.2	0.3	0.4	0.5	0.6
150	0.04	28.96	0.13	0.99	>0.99	439	513	577	635	693	758
250	0.07	25.2	0.16	0.98	>0.99	423	497	556	614	674	739
300	0.08	22.95	0.18	0.98	>0.99	417	490	549	602	661	726
350	0.10	20.94	0.20	0.97	>0.99	409	483	541	596	653	716
400	0.11	18.52	0.23	0.97	>0.99	398	472	530	584	639	701
450	0.12	16.50	0.25	0.97	>0.99	395	465	522	578	633	695
500	0.14	14.71	0.27	0.96	>0.99	392	463	520	571	625	686
550	0.15	12.81	0.30	0.95	>0.99	384	452	507	563	617	676
600	0.16	10.77	0.32	0.95	>0.99	377	444	499	553	610	671
650	0.18	8.27	0.36	0.94	>0.99	371	438	492	545	599	659
700	0.19	6.50	0.39	0.93	>0.99	364	430	485	535	588	646
725	0.20	6.09	0.40	0.93	>0.99	362	429	483	536	591	649

Scallop Production Area 2

This area is considered to be marginal habitat for scallops and is not monitored regularly. SPA 2 was last assessed in 2006 (DFO 2007).

Scallop Production Area 3

Total landings for the 2014 fishing year were 265.14 t against a TAC of 260 t in SPA 3. The commercial catch rate in 2014 for St. Mary's Bay was 26.9 kg/h, similar to the 2013 catch rate of 26.1 kg/h. June catch rates for the Brier/Lurcher area in 2014 were 21.9 kg/h, similar to 2013 (22.4 k/gh). In contrast, catch rates in Brier/Lurcher in the fall of 2013 were 22.3 kg/h; a decrease from 26.8 kg/h in 2013. The best condition factor was observed in St. Mary's Bay. Condition for SPA 3 in 2014 was 8.6 g/dm^3, a slight decrease from 2013 (9.2 g/dm^3), although similar to the long-term (1996-2013) mean of 8.7 g/dm^3. Pre-recruits were present throughout SPA 3 at varying densities, however, the largest concentration was found west of 66.5°W in the VMS (vessel monitoring system) area (Figure 1). The estimate of recruit biomass for 2014 was 34.54 t, a decrease from 60.2 t in 2013, and below the long-term (1996-2013) median of 43.7 t. Recruits were mainly distributed in the Inside VMS area and St. Mary's Bay (Figure 2). Commercial biomass distribution was patchy (Figure 3). Commercial population biomass for 2014 estimated by the model was 2,196 t (meats), which is in the healthy zone (Figure 6).

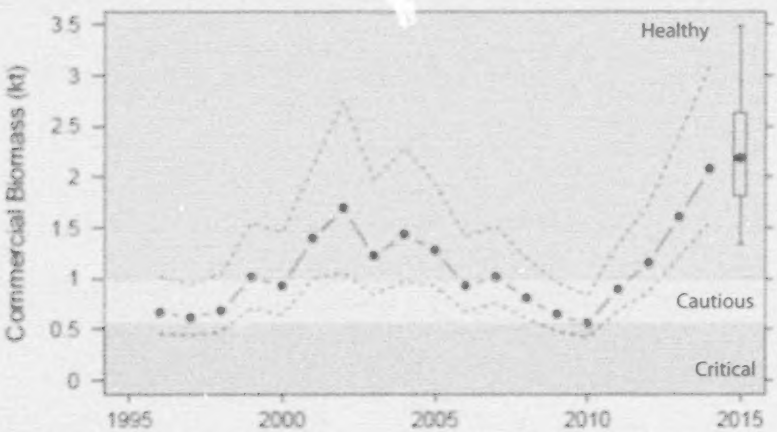

Figure 6. SPA 3 biomass estimates for commercial size scallops (kt) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2015, assuming the 2014/2015 initial TAC (125 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). Green-shaded area represents the healthy zone (based on a USR of 1000 t), yellow area represents the cautious zone (based on LRP of 590.3 t) and red is the critical zone (< LRP).

Table 3. Harvest scenario table for SPA 3 to evaluate 2014/2015 catch levels in terms of resulting exploitation (e), expected changes in biomass (%) , probability of biomass decline, probability that after removal the stock will be above the USR (1000 t), and above the LRP (590.3 t). Potential catches (t) in 2015/2016 are evaluated in terms of the posterior probability of exceeding exploitation rate of 0.15.

2014/2015						Potential catch (t) 2015/2016 $Pr(e_{2015/2016})>0.15$					
Catch (t)	e	% Change	Pr Decline	Pr >USR	Pr >LRP	0.1	0.2	0.3	0.4	0.5	0.6
150	0.06	1.15	0.49	0.98	1.00	190	241	283	325	366	413
175	0.07	0.73	0.49	0.97	1.00	188	239	281	321	362	407
200	0.08	-0.70	0.51	0.97	1.00	184	235	276	316	357	400
225	0.09	-2.04	0.53	0.97	1.00	183	233	275	316	356	400
250	0.11	-2.96	0.54	0.97	1.00	181	229	268	308	349	393
275	0.12	-4.96	0.56	0.96	1.00	179	226	265	303	343	388
300	0.13	-6.10	0.58	0.96	1.00	174	222	260	298	339	383
325	0.14	-7.50	0.60	0.96	1.00	173	221	260	297	336	379
350	0.15	-8.68	0.61	0.95	1.00	170	214	252	291	331	375
375	0.16	-9.70	0.63	0.95	1.00	169	213	252	288	327	369
400	0.17	-10.59	0.65	0.94	0.99	164	209	248	284	322	363

Scallop Production Areas 4 and 5

Before the start of the 2014 fishing year SPA 5 was joined with SPA 4 under one TAC. Total landings in the 2014 fishing year were 90.16 t in SPA 4 and 12.36 t in SPA 5 against a combined TAC of 110 t. Commercial catch rates in SPA 4 in 2014 were 22.8 kg/h, a slight increase from 2013 (20.1 kg/h) and above the long-term (1982-2013) median of 16.4 kg/h. Commercial catch rate in SPA 5 in 2014 was 22.5 kg/h, a slight increase from 2013 (19.7 kg/h) and above the long-term (1977-2013) median of 18.6 kg/h. Condition factor in SPA 4 in 2014 was 13.2 g/dm^3, a slight decrease from 2013 (13.7 g/dm^3) and above the long-term (1996-2013) average of 12.0 g/dm^3. Pre-recruits were observed in parts of SPA 4, but were not evenly distributed within the area (Figure 1). Estimated recruitment in 2014 was 90.8 t, an increase from 5.6 t in 2013 and above the long-term (1983-2013) median of 38.2 t. Recruits, when present, were relatively evenly distributed, with higher concentrations near the Mid Bay line (Figure 2). The distribution of commercial biomass in this area was relatively uniform (Figure 3). Commercial population biomass for 2014 estimated by the model was 1,152 t (meats) which is in the healthy zone (Figure 7).

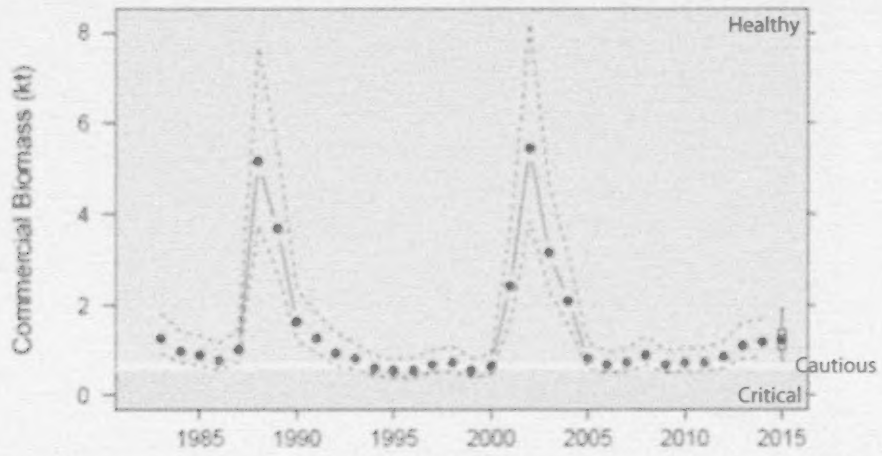

Figure 7. SPA 4 biomass estimates for commercial size scallops (kt) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2015, assuming the 2014/2015 initial TAC (75 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). Green-shaded area represents the healthy zone (based on a USR of 750 t), yellow area represents the cautious zone (based on LRP of 546 t) and red is the critical zone (< LRP).

Table 4. Harvest scenario table for SPA 4 to evaluate 2014/2015 catch levels in terms of resulting exploitation (e), expected changes in biomass (%), probability of biomass decline, probability that after removal the stock will be above the USR (750 t), and above the LRP (546 t). Potential catches (t) in 2015/2016 are evaluated in terms of the posterior probability of exceeding exploitation rate of 0.15.

2014/2015						Potential catch (t) 2015/2016					
						$Pr(e_{2015/2016})>0.15$					
Catch (t)	e	% Change	Pr Decline	Pr >USR	Pr >LRP	0.1	0.2	0.3	0.4	0.5	0.6
75	0.06	3.39	0.46	0.90	0.98	108	134	156	176	198	221
90	0.07	2.18	0.47	0.90	0.98	107	133	154	174	196	221
100	0.08	0.95	0.49	0.89	0.98	106	131	152	173	194	217
110	0.09	0.77	0.49	0.88	0.98	106	130	152	173	194	217
120	0.09	-0.75	0.51	0.88	0.98	104	129	150	169	191	216
130	0.10	-1.80	0.52	0.87	0.97	102	127	148	168	189	214
140	0.11	-2.11	0.53	0.87	0.97	103	128	148	168	189	212
150	0.12	-3.24	0.54	0.86	0.97	102	126	146	165	187	211
160	0.13	-4.00	0.55	0.85	0.97	99	124	145	164	185	209
180	0.14	-4.92	0.57	0.85	0.97	100	123	143	163	183	207
200	0.16	-7.75	0.60	0.83	0.96	98	120	141	161	181	203

The annual survey in SPA 5 was discontinued in 2009 after consultation with industry, and the sampling effort was redirected to other areas in the Bay of Fundy. In the 2014 survey, five exploratory tows were conducted in SPA 5. Shell height frequencies for the tows show a wide range of commercial scallop, with evidence of recent recruitment. The average number of commercial size scallops per tow (scallops/tow) in the exploratory tows was 181.2, above the historic long-term (1990-2008) median for the area of 79.5 commercial sized scallops/tow. The weight per tow in 2014 was 3.0 kilograms per tow (kg/tow), also above the long-term (1990-2008) median of 1.4 kg/tow. The average number of recruit sized scallops per tow (recruits/tow) was 12.8, and recruit weight per tow was 0.07 kg/tow, both below the long-term (1990-2008) recruit medians of 22.3 recruits/tow and 0.1 kg/tow.

Scallop Production Area 6

Total landings for Full Bay and Mid Bay fleets in the 2014 fishing year were 214.32 t against a combined TAC of 217 t. The commercial catch rate series starting in 1997 for all subareas combined is the stock status indicator for this area, with the LRP defined as the lowest catch rate in the series, 6.2 kg/h (1997). In 2014, the catch rate across all areas was 25.1 kg/h, an increase from 2013 (15.5 kg/h) and above the LRP (Figure 8). Catch rates from 1997 to 2001 are not presented in Figure 8 due to a change in the commercial log system implemented in 2002.

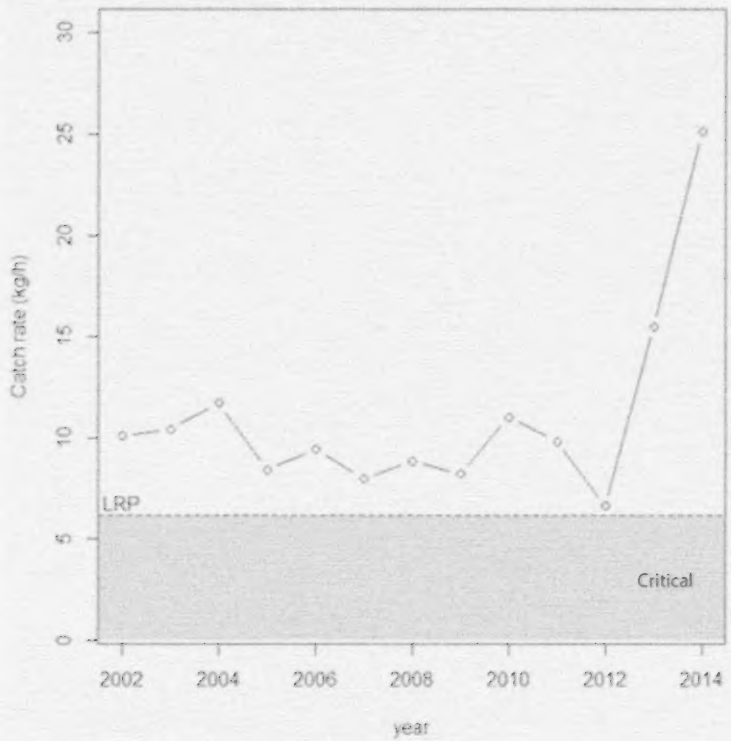

Figure 8. Annual commercial catch rate (kg/h) for SPA 6 for all subareas and both fleets combined. The red area represents the critical zone, below the LRP of 6.2 kg/h.

For analysis of SPA 6, the survey area was separated into two areas defined by VMS fishing patterns from 2002-2014, following the method used in SPA 3 (Smith et al. 2012). Indices were then calculated separately for the fished area (Inside VMS), and the unfished areas (Outside VMS). Condition factor in the Inside VMS area was 12.4 g/dm^3 in 2014, a slight decrease from 2013 (13 g/dm^3) and similar to the long-term (1997-2013) mean of 12.1 g/dm^3. Condition factor in the Outside VMS area in 2014 was 10.9 g/dm^3, similar to 2013 (11.0 g/dm^3) and above the long-term (1997-2013) mean of 9.4 g/dm^3. Pre-recruits were present throughout the SPA, with high densities found north of Grand Manan Island and south of The Wolves (Figure 1). Commercial and recruit abundance and kg/tow increased in both Inside and Outside VMS areas. Recruit scallops were present throughout the area, with the highest density occurring north of Grand Manan Island (Figure 2). Commercial and recruit abundance and kg/tow in the Inside VMS area are the highest in the time series since 2003. Commercial biomass in this area was patchy, and most of the highest density areas were Inside the VMS area (Figure 3).

The TACs set in this area since 1997 have varied, reflecting average catch trends in recent years and were not based on an assessment model or any other indicator of productivity. A total TAC of 140 t was

in place from 2007 to 2013. However, the average catch rate from 2007 to 2012 (8.6 kg/h) was almost half that observed in 2013 (15.7 kg/h). In 2014, catch rates increased significantly to 25.1 kg/h. Advice on stock status in other SPAs is provided using assessment models fit to catch and survey data. The usefulness of these models depends on the ability of the annual survey to detect changes in the population. One check of this ability has been the strength of the relationship between the survey and commercial catch rates series (which is also assumed to reflect population changes). Although the new survey index using VMS areas for all of SPA 6 appears to better track the scallop population, and has a better relationship with the commercial catch rate data than previous survey indices, this relationship is not significant and is an area of ongoing research.

While the stock assessment has made progress in refining the stock status indicators for this area, an assessment model that can be used to evaluate the impact of future catches on the population has not been developed yet. In-season advice provided for the 2014 fishing year proposed catch levels based on expected catch rate and the objective of maintaining total fishing effort at recent levels. Experience in other SPAs indicates that fishing effort is a useful proxy for exploitation, and last year's assessment showed that population numbers were at, or close to, equilibrium at recent levels of effort in this area (average effort = 9573 h, 2005-2011) (Nasmith et al. 2014). The catch rate for January 2014 was 29.92 kg/h and declined to 20.11 kg/h (Table 5) for the remainder of the fishery with a seasonal average of 25.1 kg/h, which is the highest level in the time series to date (Figure 8). Unlike the last two years, condition has not increased in 2014, although recruitment and commercial survey indices do show increases over 2013. Given these trends, average seasonal commercial catch rate in 2015 should be similar to 2014, suggesting that a catch of 240 t should not result in an increase in exploitation rate.

Table 5. Catch rate estimates (kg/h) from commercial logbooks for all of SPA 6. Estimate types: 'Actual' calculated from cleaned logs post-season; 'Predicted' in January 2014 based on logs available in-season at time of advice; and 'Predicted' Rest of Year based on January 2014 estimate and the proportional decrease in catch rate observed from previous years.

Area	Year	Estimate Type	Catch rate (kg/h)	
			January	Rest of Year
SPA 6 All	2012	Actual	7.74	5.43
	2013	Actual	17.90	12.13
	2014	Actual	29.92	20.11
	2014	Predicted	30.42	20.08

Ecosystem Considerations

There were no fisheries observer trips in the Bay of Fundy scallop fishery in the 2014 fishing year. Refer to Sameoto and Glass (2012) for past analysis of discards from the inshore scallop fishery.

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Sources of Information

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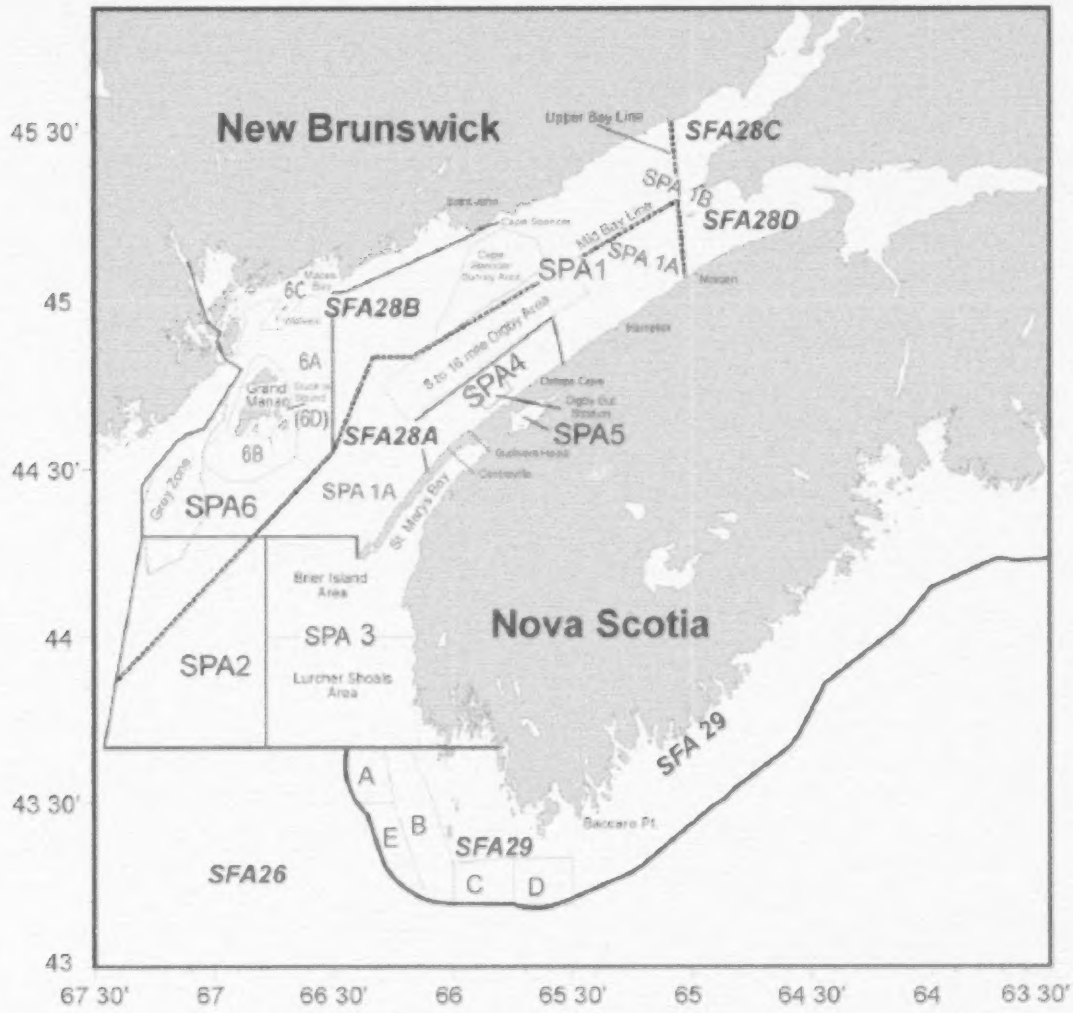
Appendix 1

Map showing the locations and place names for inshore scallop grounds.



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